(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 January 2005 (06.01.2005)

PCT

(10) International Publication Number
WO 2005/000284 A2

(51) International Patent Classification[7]: A61K 31/00

(21) International Application Number:
PCT/US2004/015653

(22) International Filing Date: 19 May 2004 (19.05.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/471,735	20 May 2003 (20.05.2003)	US
60/520,399	17 November 2003 (17.11.2003)	US
60/556,062	25 March 2004 (25.03.2004)	US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DIARYL UREAS FOR DISEASES MEDIATED BY PDGFR

(57) Abstract: The present invention provides methods for treating and/or preventing conditions and diseases in humans and other mammals that are associated with and/or mediated by signal transduction pathways comprising platelet-derived growth factor receptor (PDGFR) by administering diaryl ureas of Formula I. The present invention also provides devices and methods for treating, ameliorating, preventing, or modulating restenosis following angioplastic surgery or other invasive procedures that affect or injure the vascular system, and graft rejection following transplantation of a donor tissue into a host, where a stent or other omplantable device comprises an effective amount of diaryl ureas of Formula I.

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DIARYL UREAS FOR DISEASES MEDIATED BY PDGFR

This application claims the benefit of U.S. Provisional Application Nos. 60/556,062, filed March 25, 2004, 60/520,399, filed November 17, 2003, and 60/471,735, filed May 20, 2003, each of which are hereby incorporated by reference in their entirety.

Background of the Invention

One of the key regulators of stromal formation is the platelet-derived growth factor, also called PDGF. PDGF was originally identified as the v-sis oncogene product of the simian sarcoma virus (Heldin, C.H., et al., *J Cell Sci Suppl*, **1985**, 3, 65-76). This growth factor is made up of two peptide chains, referred to as A or B chains which share 60% homology in their primary amino acid sequence. The chains are disulfide cross linked to form the 30 kDa mature protein composed of either AA, BB or AB homo- or heterodimmers. PDGF is found at high levels in platelets, and is expressed by endothelial cells and vascular smooth muscle cells. PDGF binds with high affinity to the PDGF receptor, a 1106 amino acid 124 kDa transmembrane tyrosine kinase receptor (Heldin, C.H., A. Ostman, and L. Ronnstrand, *Biochim Biophys Acta*, **1998**. 1378(1), 79-113). PDGFR is found as homo- or heterodimer chains which have 30% homology overall in their amino acid sequence and 64% homology between their kinase domains (Heldin, C.H., et al.. *Embo J*, **1988**, 7(5), 1387-93). PDGFR is a member of a family of tyrosine kinase receptor with split kinase domains that includes VEGFR2 (KDR), c-Kit, and FLT3. The PDGF receptor is expressed primarily on fibroblast, smooth muscle cells, and pericytes and to a lesser extent on neurons, kidney mesangial, Leydig, and Schwann cells of the central nervous system. Upon binding to the receptor, PDGF induces receptor dimerization and undergoes auto- and trans-phosphorylation of tyrosine residues which increase the receptors' kinase activity and promotes the recruitment of downstream effectors through the activation of SH2 protein binding domains. A number of signaling molecules form complexes with activated PDGFR including PI-3-kinase, phospholipase C-gamma, src and GAP (GTPase activating protein for p21-ras) (Soskic, V., et al. *Biochemistry*, **1999**, 38(6), 1757-64). Through the activation of PI-3-kinase, PDGF activates the Rho signaling pathway inducing cell motility and migration, and through the activation of GAP, induces mitogenesis through the activation of p21-ras and the MAPK signaling pathway.

In adults, the major function of PDGF is to facilitate and increase the rate of wound healing and to maintain blood vessel homeostasis (Baker, E.A. and D.J. Leaper, *Wound Repair Regen*, **2000**. 8(5), 392-8; Yu, J., A. Moon, and H.R. Kim, *Biochem Biophys Res Commun*, **2001**. 282(3), 697-700). PDGF is found at high concentrations in platelets and is a potent chemoattractant for fibroblast, smooth muscle cells, neutrophils and macrophages. In addition to its role in wound healing PDGF helps maintain vascular homeostasis. During the development of new blood vessels, PDGF recruits pericytes and smooth muscle cells that are needed for the structural integrity of the vessels. PDGF is thought to play a similar role during tumor neovascularization. As part of its role in angiogenesis, PDGF controls interstitial fluid pressure, regulating the permeability of vessels through its regulation of the interaction between connective tissue cells and the extracellular matrix.

The PDGFR family of ligands is a set of homo- and heterodimeric ligands bound through a disulfide bridge that can be found in three forms, AA, AB and BB. PDGF is a potent mitogen and chemotactic factor for a variety of mesenchymal cells, such as fibroblasts, vascular smooth muscle cells, glomerular mesangial cells and brain glial cells. PDGF has been implicated in a variety of pathological conditions, including cancer, atherosclerosis, restenosis, liver cirrhosis, pulmonary fibrosis, and glomerulonephritis. PDGF exerts its biological activity by binding to the PDGF receptor (PDGFR) inducing receptor dimerization. PDGF-AA induces only α/α receptor dimers, PDGF-AB induces α/α and α/β receptor dimers, and PDGF-BB induces all three receptor dimer combinations. Once dimerized, the PDGFR undergoes trans-phosphorylation on a tyrosine, activating it for intracellular signaling interactions essential that mediate changes in gene expression, cell migration and proliferation.

Following vascular injury the restenotic reparative process is engaged, and within a few days damaged and dying vascular smooth muscle cells (vSMC) release growth factors, such as bFGF, inducing medial vSMC proliferation over the next 3-5 days. The vSMC migrate to the neointima, where approximately half undergo cell cycle proliferation in the intima, and the other half do not divide. PDGF-BB may be a central chemotactic factor involved in wound healing following vascular trauma because it is both mitogenic for cultured vSCM through activation of PDGF receptors, and chemotactic through activation of PDGFRβ. *In vivo*, PDGF-BB acts

predominantly as a chemotactic factor on vSMC. Injection of PDGF-BB has been shown to increase vSMC migration by greater than 10-fold, but proliferation by only 2-fold (A. Jawein et al. *J. Clin. Invest.* **1992**, *89*, 507). In addition, anti-PDGF antibodies have been shown to block migration of vSMC, but not their proliferation (G.A.A. Ferns *Science* **1991**, *253*, 1129). The PDGFR inhibitor RPR101511A prevented angiographically defined restenosis following angioplasty (G. Bilder et al. *Circulation* **1999**, *99*, 3292). Similarly, the PDGFR inhibitor CT52923 was shown to inhibit neointima formation following carotid artery injury in the rat in *in vivo* studies (J.-C. Yu et al. *J. Pharmacol. Exp. Therap.* **2001**, *298*, 1172).

Signal transduction through PDGFR has been linked to vascular smooth muscle cell (vSMC) migration and proliferation leading to allograft vasculopathy and ultimately graft rejection. The PDGFR inhibitor AG-1295 was shown to reduce neointimal formation in aortic allograft vasculopathy in a rat model of neointimal formation (M. Karck et al. *Transplantation* **2002**, *74*, 1335).

Despite the biological evidence that PDGFR inhibitors known in the art have the potential to be used in medicines, there remains a need for new inhibitors of this receptor tyrosine kinase.

Diarylureas are a class of serine-threonine kinase inhibitors as well as tyrosine kinase inhibitors well known in the art. The following publications illustrate their utility as an active ingredient in pharmaceutical compositions for the treatment of cancer, angiogenesis disorders, and inflammatory disorders:

Redman et al., *Bioorg. Med. Chem. Lett.* **2001**, *11*, 9-12.

Smith et al., *Bioorg. Med. Chem. Lett.* **2001**, *11*, 2775-2778.

Dumas et al., *Bioorg. Med. Chem. Lett.* **2000**, *10*, 2047-2050.

Dumas et al., *Bioorg. Med. Chem. Lett.* **2000**, *10*, 2051-2054.

Ranges et al., *Book of Abstracts, 220th ACS National Meeting, Washington, DC, USA, MEDI 149.*

Dumas et al., *Bioorg. Med. Chem. Lett.* **2002**, *12*, 1559-1562.

Lowinger et al., *Clin. Cancer Res.* **2000**, *6(suppl.)*, 335.

Lyons et al., *Endocr.-Relat. Cancer* **2001**, *8*, 219-225.

Riedl et al., *Book of Abstracts, 92nd AACR Meeting, New Orleans, LA, USA, abstract 4956.*

Khire et al., *Book of Abstracts, 93rd AACR Meeting, San Francisco, CA, USA, abstract 4211.*

Lowinger et al., *Curr. Pharm. Design* **2002**, *8*, 99-110.

Regan et al., *J. Med. Chem.* **2002**, *45*, 2994-3008.

Pargellis et al., *Nature Struct. Biol.* **2002**, *9(4)*, 268-272.

Carter et al., *Book of Abstracts, 92nd AACR Meeting, New Orleans, LA, USA, abstract 4954.*

Vincent et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 1900.*

Hilger et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 1916.*

Moore et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 1816.*

Strumberg et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 121.*

Madwed JB: *Book of Abstracts, Protein Kinases: Novel Target Identification and Validation for Therapeutic Development, San Diego, CA, USA, March 2002.*

Roberts et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 473.*

Tolcher et al., *Book of Abstracts, 38th ASCO Meeting, Orlando, FL, USA, abstract 334.*

Karp et al., *Book of Abstracts, 38th AACR Meeting, San Francisco, CA, USA, abstract 2753.*

Description of the Invention

The present invention provides methods for treating, ameliorating, preventing, modulating, etc., conditions and diseases in humans and other mammals that are associated with and/or mediated by signal transduction pathways comprising platelet-derived growth factor receptor (PDGFR). Methods of the present invention especially provide for modulating diseases and conditions associated and/or mediated by PDGFR-beta.

In particular, the present invention provides devices (e.g., stents and other materials in contact with blood and/or cells), compositions, and methods for treating, ameliorating, preventing, or modulating restenosis following angioplastic surgery or other invasive procedures that affect the vascular system, and graft rejection following transplantation of a donor tissue into a host. The methods can comprise, e.g.,

administering an aryl urea compound as described below, pharmaceutically-acceptable salts thereof, and prodrugs thereof.

The compounds of the present invention can be utilized to treat any conditions or diseases mediated by PDGFR-beta, including any unwanted and/or deleterious consequence of an invasive procedures performed on the body, especially to the vascular system, including, but not limited to, angioplasty, atherectomy, arterial grafting, vessel wall stenting, and endarterectomy. The compounds can be applied directly to the affected area (e.g., in combination with a material or carrier designed to release the compound) or on a device or material that is introduced into the target site.

The aryl urea compounds employed in the methods of this invention comprise compounds of Formula I, pharmaceutically acceptable salts thereof, prodrugs thereof, and any active derivatives thereof, which are collectively referred to herein as the "compounds of the invention" and the like.

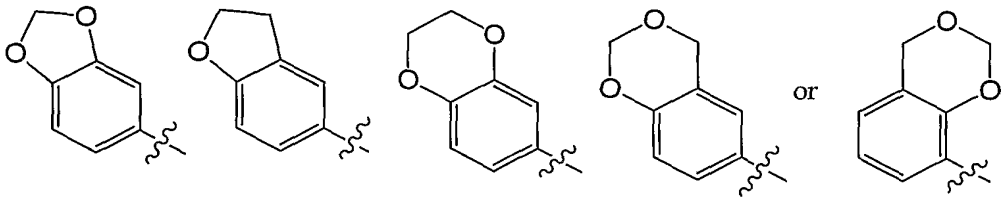
Formula I is as follows:

A-NH-C(O)-NH-B-L-M-Q (I)

wherein

A is phenyl, optionally substituted with 1-3 substituents independently selected from the group consisting of C_1-C_5 alkyl, C_1-C_5 halogenoalkyl, up to perhaloalkyl, C_1-C_5 alkoxy, halogen, cyano, and nitro;

Alternatively, A is a group of the formula:



optionally substituted with 1-6 substituents selected from C_1-C_5 alkyl and halogen;

B is phenylene or naphthylene, optionally substituted with 1-3 substituents independently selected from the group consisting of C_1-C_5 alkyl, C_1-C_5 halogenoalkyl, up to perhaloalkyl, C_1-C_5 alkoxy, halogen, cyano, and nitro;

L is a linker selected from -O- or -S-;

M is a pyridine ring, optionally substituted with C_1-C_5 alkyl, C_1-C_5 halogenoalkyl, up to perhaloalkyl, C_1-C_5 alkoxy, halogen, and hydroxy; and

Q is cyano, -C(O)-R_1, or -C(O)-NR_1R_2, where R_1 and R_2 are independently selected from H or lower alkyl.

Suitable C_1-C_5 alkyl groups include methyl, ethyl, propyl, butyl, and pentyl, as well as branched isomers such as isopropyl, isobutyl, *sec*-butyl, *tert*-butyl, etc. The term "C_1-C_5 alkoxy" means a straight or branched chain alkoxy grouphaving saturated carbon atoms which may be linear or branched with single or multiple branching, and includes such groups as methoxy, ethoxy, *n*-propoxy, isopropoxy, and the like. It also includes halogenated groups such as 2,2-dichloroethoxy, trifluoromethoxy, and the like.

Suitable halogens include F, Cl, Br, and/or I, from one to per-substitution (i.e. all H atoms on a group replaced by a halogen atom) being possible where an alkyl group is substituted by halogen, mixed substitution of halogen atom types also being possible on a given moiety. Preferred halogens are Cl, Br and F.

The term "C_1-C_5 halogenoalkyl, up to perhaloalkyl" includes alkyl groups having one or more alkyl hydrogens replaced with halogen, and alkyl groups having all alkyl hydrogens replaced by halogen. Examples include chloromethyl, dichloromethyl, trichloromethyl, fluoromethyl, difluoromethyl, trifluoromethyl, and the like.

When any moiety is "substituted," it can have up to the highest number of indicated substituents, and each substituent can be located at any available position on the moiety and can be attached through any available atom on the substituent. "Any available position" means any position on the moiety that is chemically accessible through means known in the art or taught herein and that does not create an unduly unstable molecule. When there are two or more substituents on any moiety, each substituent is defined independently of any other substituent and can, accordingly, be the same or different. The term "optionally substituted" means that the moiety so modified may be either unsubstituted, or substituted with the identified substituent(s).

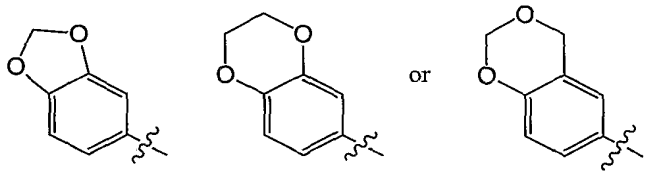
It is understood that since M is pyridine, the term "hydroxy" as an optional pyridine substituent includes 2-, 3-, and 4-hydroxypyridine, but also includes those structures referred to in the art as 1-oxopyridine, 1-hydroxypyridine and pyridine *N*-oxide.

Where the plural form of the word compounds, salts, and the like, is used herein, this is taken to mean also a single compound, salt, or the like.

Compounds of the invention of particular interest include those of Formula I wherein B is phenylene, optionally substituted with halogen.

Compounds of the invention of particular interest also include those of Formula I wherein L is -O-.

Compounds of the invention of particular interest also include those of Formula I wherein A is phenyl, substituted with 1-3 substituents selected from the group consisting of C_1-C_5 alkyl, C_1-C_5 halogenoalkyl, up to perhaloalkyl, C_1-C_5 alkoxy, and halogen, or A is a group of the formula:



optionally substituted with 1-6 halogen atoms.

Compounds of the invention of particular interest also include those of Formula I wherein:

A is 4-chloro-3-trifluoromethylphenyl, 4-fluoro-3-trifluoromethylphenyl, 4-bromo-3-trifluoromethylphenyl, or 2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxin-6-yl;

B is phenylene, chlorophenylene or fluorophenylene;

L is -O-;

M is pyridine or 1-hydroxypyridine; and

Q is cyano, C(O)-NH_2, or C(O)-NHMe.

Compounds of the invention of particular interest also include those selected from:

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-carbamoyl-4-pyridyloxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-carbamoyl-4-pyridyl oxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-fluoro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea,

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-*N*'-(4-(2-cyano-4-pyridyloxy) phenyl) urea, and

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-*N*'-(4-(2-cyano-4-pyridyloxy)-2-fluorophenyl) urea.

Compounds of the present invention can exist in different geometrical isomeric forms. All such configurations (including enantiomers and diastereomers), are included within the scope of the present invention. A number of the compounds of Formula I possess asymmetric centers, depending on the location a nature of various substituents. These compounds can therefore exist in racemic and optically active forms as well as in the form of racemic or non-racemic mixtures thereof, and in the form of diastereomers and diastereomeric mixtures. Asymmetric carbon atoms may be present in the (*R*) or (*S*) configuration or (*R,S*) configuration. In certain instances, asymmetry may also be present due to restricted rotation about a given bond, for example, the central bond adjoining two substituted aromatic rings of the specified compounds. All of these compounds, including *cis* isomers, *trans* isomers, diastereomic mixtures, racemates, non-racemic mixtures of enantiomers, substantially

pure, and pure enantiomers, are considered to be within the scope of the compounds of this invention and are collectively referred to when reference is made to compounds of this invention. Therefore, the methods of the present invention encompass the use of any isolated racemic or optically active form of compounds described in Formula I which possess PDGFR inhibitory activity.

Methods of separation of enantiomeric and diastereomeric mixtures are well known to one skilled in the art. The optical isomers may be obtained by resolution of the racemic mixtures according to conventional processes, for example, by the formation of diastereoisomeric salts using an optically active acid or base. Examples of appropriate acids are tartaric, diacetyltartaric, dibenzoyltartaric, ditoluoyltartaric and camphorsulfonic acid. Mixtures of diastereoisomers can be separated into their individual diastereomers on the basis of their physical chemical differences by methods known to those skilled in the art, for example, by chromatography or fractional crystallization. The optically active bases or acids are liberated from the separated diastereomeric salts.

Another process for separation of optical isomers involves the use of a chiral chromatography column (e.g., chiral HPLC columns) optimally chosen to maximize the separation of the enantiomers. Suitable chiral HPLC columns are manufactured by Diacel, e.g., Chiracel OD and Chiracel OJ. The optically active compounds of Formula (I) can likewise be obtained by utilizing optically active starting materials. The present invention encompasses any separated, isolated, pure or partially purified isomers or racemic mixtures of the compounds of formula I which possess PDGFR inhibitory activity, and/or an efficacy in modulating any of the diseases and/or conditions mentioned herein. The term stereoisomer is understood to encompass diastereoisomers, enantiomers, geometric isomers, etc.

Preferred compounds are those with the absolute configuration of the compound of Formula I which produce the more desirable biological activity are also included within the scope of the present invention. The purification of said isomers and the separation of said isomeric mixtures can be accomplished by standard techniques known in the art. The phrase "substantially pure enantiomers" means that no more than about 5% w/w of the corresponding opposite enantiomer is present.

Pharmaceutically-acceptable salts of these compounds, as well as commonly used prodrugs of these compounds, are also within the scope of the invention. The term "pharmaceutically acceptable salt" refers to a relatively non-toxic, inorganic, or

organic acid addition salt of a compound of the present invention. For example, see S. M. Berge, *et al.* "Pharmaceutical Salts," *J. Pharm. Sci.* **1977**, 66, 1-19.

Suitable salts are especially the pharmaceutically acceptable salts of compounds of formula (I) or such as, for example, organic or inorganic acid addition salts of compounds of formula (I). Suitable acid addition salts include acetate, adipate, alginate, ascorbate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, citrate, camphorate, camphorsulfonate, cinnamate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, fumarate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxyethanesulfonate, itaconate, lactate, maleate, mandelate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, oxalate, pamoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, sulfonate, tartrate, thiocyanate, tosylate, and undecanoate. Suitable inorganic acids include but are not limited to halogen acids (such as hydrochloric acid and hydrobromic acid), sulfuric acid, or phosphoric acid. Suitable organic acids include but are not limited to carboxylic, phosphonic, sulfonic, or sulfamic acids, with examples including acetic acid, propionic acid, octanoic acid, decanoic acid, trifluoroacetic acid, dodecanoic acid, glycolic acid, lactic acid, 2- or 3-hydroxybutyric acid, γ-aminobutyric acid (GABA), gluconic acid, glucosemonocarboxylic acid, benzoic acid, salicylic acid, phenylacetic acid and mandelic acid, fumaric acid, succinic acid, adipic acid, pimelic acid, suberic acid, azeiaic acid, maleic acid, tartaric acid, citric acid, glucaric acid, galactaric acid, amino acids (such as glutamic acid, aspartic acid, N-methylglycine, acetytaminoacetic acid, N-acetylasparagine or N-acetylcysteine), pyruvic acid, acetoacetic acid, methanesulfonic acid, trifluoromethanesulfonic acid, 4-toluene sulfonic acid, benzenesulfonic acid, 1-naphthalenesulfonic acid, 2-naphthalenesulfonic acid, phosphoserine, and 2- or 3-glycerophosphoric acid.

In addition, pharmaceutically acceptable salts include acid salts of inorganic bases, such as salts containing alkaline cations (e.g., Li^+, Na^+, or K^+), alkaline earth cations (e.g., Mg^{+2}, Ca^{+2}, or Ba^{+2}), the ammonium cation, as well as acid salts of organic bases, including aliphatic and aromatic substituted ammonium, and quaternary ammonium cations, such as those arising from protonation or peralkylation of triethylamine, *N,N*-diethylamine, *N,N*-dicyclohexylamine, lysine, pyridine, *N,N*-dimethylaminopyridine (DMAP), 1,4-diazabiclo[2.2.2]octane (DABCO), 1,5-diazabicyclo[4.3.0]non-5-ene (DBN) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU).

Base salts include alkali metal salts such as potassium and sodium salts, alkaline earth metal salts such as calcium and magnesium salts, and ammonium salts with organic bases such as dicyclohexylamine and N-methyl-D-glucamine. Additionally, basic nitrogen containing groups may be quaternized with such agents as lower alkyl halides such as methyl, ethyl, propyl, and butyl chlorides, bromides and iodides; dialkyl sulfates like dimethyl, diethyl, and dibutyl sulfate; and diamyl sulfates, long chain halides such as decyl, lauryl, myristyl and strearyl chlorides, bromides and iodides, aralkyl halides like benzyl and phenethyl bromides and others.

The formation of prodrugs is well known in the art in order to enhance the properties of the parent compound; such properties include solubility, absorption, biostability and release time (see *"Pharmaceutical Dosage Form and Drug Delivery Systems"* (Sixth Edition), edited by Ansel et al., published by Williams & Wilkins, pages 27-29, (1995) which is hereby incorporated by reference). Major drug biotransformation reactions include N-dealkylation, O-dealkylation, aliphatic hydroxylation, aromatic hydroxylation, N-oxidation, S-oxidation, deamination, hydrolysis reactions, glucuronidation, sulfation and acetylation (see *Goodman and Gilman's The Pharmacological Basis of Therapeutics* (Ninth Edition), editor Molinoff et al., pub. by McGraw-Hill, pages 11-13, (1996), which is hereby incorporated by reference).

The potent inhibitory activity of N-[4-chloro-3-(trifluoromethyl)phenyl]-N'-{4-[2-N-methylcarbamoyl-4-pyridyloxy]phenyl} urea, a compound of the present invention, as well as several of its analogs described herein, has been demonstrated in *in vitro* (biochemical) and *in vivo* (cellular) assays of PDGFR activity.

While not wishing to be bound by any theory or mechanism of action, it has been found that compounds of the present invention possess the ability to modulate PDGFR kinase activity. The methods of the present invention, however, are not limited to any particular mechanism or how the compounds achieve their therapeutic effect. By the term "modulate," it is meant that the functional activity of the pathway (or a component of it) is changed in comparison to its normal activity in the absence of the compound. This effect includes any quality or degree of modulation, including, increasing, agonizing, augmenting, enhancing, facilitating, stimulating, decreasing, blocking, inhibiting, reducing, diminishing, antagonizing, etc.

By the phrase "kinase activity," it is meant a catalytic activity in which a gamma-phosphate from adenosine triphosphate (ATP) is transferred to an amino acid

residue (e.g., serine, threonine, or tyrosine) in a protein substrate. A compound can modulate kinase activity, e.g., inhibiting it by directly competing with ATP for the ATP-binding pocket of the kinase, by producing a conformational change in the enzyme's structure that affects its activity (e.g., by disrupting the biologically-active three-dimensional structure), etc.

Kinase activity can be determined routinely using conventional assay methods. Kinase assays typically comprise the kinase enzyme, substrates, buffers, and components of a detection system. A typical kinase assay involves the reaction of a protein kinase with a peptide substrate and an ATP, such as ^{32}P-ATP, to produce a phosphorylated end-product (for instance, a phosphoprotein when a peptide substrate is used. The resulting end-product can be detected using any suitable method. When radioactive ATP is utilized, a radioactively labeled phosphoprotein can be separated from the unreacted gamma-32P-ATP using an affinity membrane or gel electrophoresis, and then visualized on the gel using autoradiography or detected with a scintillation counter. Non-radioactive methods can also be used. Methods can utilize an antibody that recognizes the phosphorylated substrate, e.g., an anti-phosphotyrosine antibody. For instance, kinase enzyme can be incubated with a substrate in the presence of ATP and kinase buffer under conditions that are effective for the enzyme to phosphorylate the substrate. The reaction mixture can be separated, e.g., electrophoretically, and then phosphorylation of the substrate can be measured, e.g., by Western blotting using an anti-phosphotyrosine antibody. The antibody can be labeled with a detectable label, e.g., an enzyme, such as HRP, avidin or biotin, chemiluminescent reagents, etc. Other methods can utilize ELISA formats, affinity membrane separation, fluorescence polarization assays, luminescent assays, etc.

An alternative to a radioactive format is time-resolved fluorescence resonance energy transfer (TR-FRET). This method follows the standard kinase reaction, where a substrate, e.g., biotinylated poly(GluTyr), is phosphorylated by a protein kinase in the presence of ATP. The end-product can then detected with a europium chelate phosphospecific antibody (anti-phosphotyrosine or phosphoserine/threonine), and streptavidin-APC, which binds the biotinylated substrate. These two components are brought together spatially upon binding, and energy transfer from the phosphospecific antibody to the acceptor (SA-APC) produces fluorescent readout in the homogeneous format.

The compounds of the present invention can be used to treat and/or prevent any disease or condition mediated by signal transduction pathways comprising platelet-derived growth factor receptor (PDGFR). A disease or condition "mediated" by PDGFR indicates that receptor is a part of a signal transduction pathway that is involved in any aspect of the disease phenotype (e.g., where a defect in the receptor itself is involved in "causing" the disease; where stimulation of the receptor by its ligand induces cell motility, migration, and/or proliferation that produces a disease phenotype; where receptor stimulation or phosphorylation results in restonosis; any functional activity of PDGFR that, when inappropriately expressed, results in a disease symptom and/or phenotype). The term "treating" is used conventionally, e.g., the management or care of a subject for the purpose of combating, alleviating, reducing, relieving, improving the condition of, etc., of a disease or disorder. Diseases and conditions that can be treated include, but are not limited to the prevention of restenosis and graft rejection.

The following patents and publication relate to PDGF/PDGFR inhibition and are incorporated herein for their description of the disease states mediated by PDGFR-beta and assays to determine such activity.

US 5,094,941	Hart, et al.
US 5,371,205	Kelly, et al.
US 5,418,135	Pang
US 5,444,151	Vassbotn, et al.
US 5,468,468	LaRochelle, et al.
US 5,567,584	Sledziewski, et al.
US 5,618,678	Kelly, et al.
US 5,620,687	Hart, et al.
US 5,648,076	Ross, et al.
US 5,668,264	Janjic, et al.
US 5,686,572	Wolf, et al.
US 5,817,310	Ramakrishnan, et al.
US 5,833,986	LaRochelle, et al.
US 5,863,739	LaRochelle, et al.
US 5,872,218	Wolf, et al.
US 5,882,644	Chang, et al.
US 5,891,652	Wolf, et al.

US 5,976,534 Hart, et al.
US 5,990,141 Hirth, et al.
US 6,022,854 Shuman
US 6,043,211 Williams, et al.
US 6,110,737 Escobedo, et al.
US 6,207,816B1 Gold, et al.
US 6,228,600B1 Matsui, et al.
US 6,229,002B1 Janjic, et al.
US 6,316,603B1 McTigue, et al.
US 6,372,438B1 Williams, et al.
US 6,403,769B1 La Rochelle, et al.
US 6,440,445B1 Nowak, et al.
US 6,475,782B1 Escobedo, et al.
WO02/083849 Rosen, et al.
WO02/083704 Rosen, et al.
WO02/081520 Boesen, et al.
WO02/079498 Thomas, et al.
WO02/070008 Rockwell, et al.
WO099/59636 Sato, et al.
WO099/46364 Cao, et al.
WO099/40118 Hanai, et al.
WO99/31238 Yabana, et al.
WO99/29861 Klagsbrun, et al.
WO98/58053 Kendall, et al.
WO98/51344 Maini, et al.
WO98/33917 Alitalo, et al.
WO98/31794 Matsumoto, et al.
WO98/16551 Ferrara, et al.
WO98/13071 Kendall, et al.
WO98/11223 Martiny-Baron, et al.
WO97/44453 Chen, et al.
WO97/23510 Plouet, et al.
WO9715662 Stinchcomb, et al.
WO97/08313 Ferrara, et al.

WO96/39515	Cao, et al.
WO96/23065	Smith, et al.
WO96/06641	Fleurbaaij, et al.
WO95/24473	Cao, et al.
WO98/22316	Kyowa
WO95/21868	Rockwell, et al.
WO02/060489	Xia, et al.

PDGFR-beta

EP0869177	Matsui, et al.
WO090/10013	Matsui, et al.
WO97/37029	Matsui, et al.

PDGFR-alpha

EP1000617	Lammers, et al.
EP0869177	Matsui, et al.
EP0811685	Escobedo, et al.

PDGFR-beta mediated diseases include, e.g., diseases or conditions characterized by cell proliferation, cell matrix production, cell movement, and/or extracellular matrix production. Specific examples, include, e.g., tumors, malignancies, cancer, metastasis, chronic myeloid leukemia, inflammation, renal disease, diabetic nephropathy, mesangial proliferative glomerulonephritis, fibrotic conditions, atherosclerosis, restenosis, hypertension-related arteriosclerosis, venous bypass graft arteriosclerosis, scleroderma, interstitial pulmonary diseases, synovial disorders, arthritis, leukemias, lymphomas, etc.

Devices and other materials comprising compounds

The present invention also relates to devices and other blood and cell contacting materials, such as vascular grafts, cardiac valves, stents, and catheters, which comprise compounds of the present invention.

Percutaneous transluminal coronary angioplasty (PTCA) is widely used to treat patients with coronary artery disease. PTCA can relieve myocardial ischemia in patients with coronary artery disease by reducing lumen obstruction and improving

coronary flow. However, stenosis following PTCA is a significant problem, with about 25% to 35% of the patients developing restenosis within 1 to 3 months. Stents (e.g., a metal tube or scaffold) and other devices have been used to address the complications associated with PTCA. Although the rates of restenosis have been lowered, many patients still experienced re-blocking of the arteries, requiring repeat procedures. To confront these problems, stents have been coated with a variety of different materials and active agents to interrupt the biological processes that cause restenosis. Accordingly, the present invention provides an implantable medical device, such as a stent or graft, which comprises one or more compounds of the present invention.

Stents are scaffoldings, typically cylindrical or tubular in shape, which are inserted into an anatomical channel to physically hold it open, and if desired, to expand the walls of the channel. Stents can be crimped on to balloon catheters for insertion through small cavities, positioned in a desired location, and then expanded to a larger diameter. Stents can be either balloon expandable or self-expanding.

Grafts are typically placed in a blood vessel to either replace a diseased segment that has been removed, or to form a bypass conduit through a damaged segment of the vessel wall as is the case with an aneurysm, for example. The graft has a tubular portion that spans the site of the damaged tissue and through which the blood flows. The graft has sections at both ends of the tube that are used to secure the graft to the inside of a vessel wall. The graft also has an outer surface, portions of which are in contact with an inner surface of the blood vessel wall, and an inner surface in contact with the blood flowing through the vessel.

Stents can be of any design or shape that is useful for the desired purpose. For example, stents can be balloon expandable, self-expanding, tube, wire, sheet, ribbon, coil, helical spiral, woven, comprising individual rings, comprising sequential rings, closed cell, open cell, spiral articulated slotted tube, sinusoidal pattern, helical fused sinusoidal elements, corrugated ring, Wiktor tantalum stent, etc. Commercially available stents include, Cordis Palmaz-Schatz, Cordis Crown, Bx-Veclocity, S670, S7, ACS Multi-Link, Multi-Link Tetra, Multi-Link Penta, NIR, and Express. They can be made of any suitable material(s), including, e.g., stainless steel, gold, platinum iridium, polymers, niobium alloy, cobalt alloys, nickel-titanium, cobalt-chromium, etc.

Active agents can be coated directly on to an implantable medical device, or impregnated or otherwise associated with a material or carrier (e.g., a polymeric substance) which is then placed in contact with it. Once the stent or graft is implanted within a cardiovascular system lumen, the active agent is released, thereby resulting in its delivery to the local tissues. These can also be referred to as coated, medicated, or drug-eluting implantable devices. Metallic designs can be coated with thin (e.g., 5-10 micrometers) elastomeric biostable polymer surface membrane coatings which comprise the active compound. The stent backbone can also comprise drilled holes or wells that comprise the drug (e.g., in a polymeric time-release substrate). Alternatively, it can be present in a film that is cast on the stent backbone.

Any method of associating a compound of the present invention with an implantable device can be used. Compounds can be embedded, implanted, coated, impregnated, layered, covered, etc. directly on to the device, or otherwise associated with a carrier material. There are many examples of implantable devices, drug-eluting devices, materials to achieve drug delivery, etc., and the present invention is not limited by which are utilized. See, e.g., Waksman, Cardiovasc Radiat Med. 2002 Jul-Dec;3(3-4):226-41; Eberhart et al., J Biomater Sci Polym Ed. 2003;14(4):299-312; Wieneke et al., Expert Opin Investig Drugs. 2003 May;12(5):771-9; Tsuji et al., Int J Cardiovasc Intervent. 2003;5(1):13-6; U.S. Pat. Nos. 6,712,845; 6,709,514; 6,702,850; 6,673,385; 6,673,154; 6,620,194; 6,613,084; 6,589,546; 6,585,765; 6,574,851; 6,569,195; 6,555,157; 6,545,097; 6,530,951; 6,475,235; 6,395,326; 6,375,677; 6,364,893; 6,358,556; 6,335,029; 6,316,018; 6,273,908; 6,258,121 ;6,245,102; 6,179,789; 6,080,190; 5,879,697; 5,876,433; 5,527,324; 5,469,868; 5,464,650; 5,700,286; 5,605,696. The compound can be combined with materials which controllably-release it into the system, e.g., to achieve steady-state concentrations of the compound.

The devices can further comprise any pharmacological or active agent which is useful for treating and/or preventing restenosis, including, but not limited to, antibiotic, antineoplastic, anti-inflammatory, antiplatelet, anticoagulant, fibrinolytic, thrombin inhibitor, antimitotic, and antiproliferative agents.

The present invention provides an intravascular stent for introduction into a vascular lumen, comprising, e.g., an elongated body having surfaces, wherein said surfaces comprise an effective amount of a compound of the present invention to prevent and/or treat and/or delay restenosis. The stent can have inner and outer

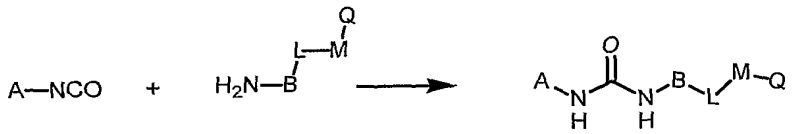
surfaces, where one surface or both are coated with compounds. The stent can have any structure as mentioned above, e.g., a scaffold or backbone that is expandable, self-expanding, tube, wire, sheet, ribbon, coil, helical spiral, woven, etc. The surfaces of the stent can be coated directly with the compound, or associated with a carrier or substrate that comprises the compound, e.g., where the substrate or carrier is impregnated with a compound of formula I. The stent can have any suitable geometry, e.g., an elongated body which is substantially cylindrical.

General Preparative Methods

The diaryl ureas of Formula I may be prepared by the use of known chemical reactions and procedures, some from starting materials that are commercially available. Nevertheless, general preparative methods are provided below to aid one skilled in the art in synthesizing these compounds.

The following general preparative methods are presented to aid the reader in synthesizing the compounds of the present invention. All variable groups of these methods are as described in the generic description if they are not specifically defined below. It is recognized that compounds of the invention with each claimed optional functional group cannot be prepared with each of the below-listed methods. Within the scope of each method optional substituents are used which are stable to the reaction conditions, or the functional groups which may participate in the reactions are present in protected form where necessary, and the removal of such protective groups is completed at appropriate stages by methods well known to those skilled in the art.

General Method



II III I

The urea compounds (I) can be synthesized as above by reacting amino compounds (III) with isocyanate compounds (II).

The compounds (II) are commercially available or can be synthesized according to methods commonly known to those skilled in the art [e.g. from treatment of an amine with phosgene or a phosgene equivalent such as trichloromethyl chloroformate (diphosgene), bis(trichloromethyl)carbonate (triphosgene), or *N,N'*-carbonyldiimidazole (CDI); or, alternatively by a Curtius-type rearrangement of an amide, or a carboxylic acid derivative, such as an ester, an acid halide or an anhydride]. The compounds (III) can be synthesized according methods commonly known to those skilled in the art.

In addition, specific preparations of diaryl ureas of Formula (I) are already described in the patent literature, and can be adapted to the compounds of the present invention. For example, Miller S. et al, "Inhibition of p38 Kinase using Symmetrical and Unsymmetrical Diphenyl Ureas" *PCT Int. Appl.* WO 99 32463, Miller, S et al. "Inhibition of raf Kinase using Symmetrical and Unsymmetrical Substituted Diphenyl Ureas" *PCT Int. Appl.,* WO 99 32436, Dumas, J. et al., "Inhibition of p38 Kinase Activity using Substituted Heterocyclic Ureas" *PCT Int. Appl.,* WO 99 32111, Dumas, J. et al., "Method for the Treatment of Neoplasm by Inhibition of raf Kinase using N-Heteroaryl-N'-(hetero)arylureas" *PCT Int. Appl.,* WO 99 32106, Dumas, J. et al., "Inhibition of p38 Kinase Activity using Aryl- and Heteroaryl- Substituted Heterocyclic Ureas" *PCT Int. Appl.,* WO 99 32110, Dumas, J., et al., "Inhibition of raf Kinase using Aryl- and Heteroaryl- Substituted Heterocyclic Ureas" *PCT Int. Appl.,* WO 99 32455, Riedl, B., et al., "O-Carboxy Aryl Substituted Diphenyl Ureas as raf Kinase Inhibitors" *PCT Int. Appl.,* WO 00 42012, Riedl, B., et al., "O-Carboxy Aryl Substituted Diphenyl Ureas as p38 Kinase Inhibitors" *PCT Int. Appl.,* WO 00 41698, Dumas, J. et al. "Heteroaryl ureas containing nitrogen hetero-atoms as p38 kinase inhibitors" *U.S. Pat. Appl. Publ.,* US 20020065296, Dumas, J. et al. "Preparation of N-aryl-N'-[(acylphenoxy) phenyl]ureas as raf kinase inhibitors" *PCT Int. Appl.,* WO 02 62763, Dumas, J. et al. "Inhibition of raf kinase using quinolyl, isoquinolyl or pyridyl ureas" *PCT Int. Appl.,* WO 02 85857, Dumas, J. et al. "Preparation of quinolyl, isoquinolyl or pyridyl-ureas as inhibitors of raf kinase for the treatment of tumors and/or cancerous cell growth" *U.S. Pat. Appl. Publ.,* US 20020165394, Carter, C. A. et al. "Aryl urea compounds in combination with other cytostatic or cytotoxic agents for treating human cancers and other raf kinase-mediated diseases" *PCT Int. Appl.,* WO 03 47579, Riedl, B. et al. "Omega-carboxyaryl substituted diphenyl ureas as raf kinase inhibitors" *U.S. Pat. Appl. Publ.*

US 20030144278, Dumas, J. et al. "Aryl ureas with raf kinase and angiogenesis inhibiting activity" *PCT Int. Appl.*, WO 03 68223, Dumas, J. et al. "Aryl ureas with angiogenesis inhibiting activity" *PCT Int. Appl.*, WO 03 68228, Dumas, J. et al. "Pyridine, quinoline, and isoquinoline N-oxides as kinase inhibitors" *PCT Int. Appl.*, WO 03 68229, Dumas, J. et al. "Aryl ureas as kinase inhibitors" *PCT Int. Appl.*, WO 03 68746; U.S. Provisional Application Nos. 60/540,326, 60/489,102, and 536,734.

The reaction of the compounds (II) with (III) is carried out preferably in a solvent. Suitable solvents comprise the customary organic solvents which are inert under the reaction conditions. Non-limiting examples include ethers such as diethyl ether, dioxane, tetrahydrofuran, 1,2-dimethoxy ethane; hydrocarbons such as benzene, toluene, xylene, hexane, cyclohexane, mineral oil fractions; halogenated hydrocarbons such as dichloromethane, trichloromethane, carbon tetrachloride, dichloroethane, trichloroethylene, chlorobenzene; alcohols such as methanol, ethanol, n-propanol, isopropanol; esters such as ethyl acetate; ketones such as acetone; nitriles such as acetonitrile; heteroaromatics such as pyridine; polar solvents such as dimethyl formamide and hexamethyl phosphoric acid tris-amide; and mixtures of the above-mentioned solvents. Toluene, benzene, and dichloromethane are preferred.

The compounds (III) are generally employed in an amount of from 1 to 3 mol per mol of compounds (II); an equimolar amount or slight excess of compounds (III) is preferred.

The reaction of the compounds (II) with (III) is generally carried out within a relatively wide temperature range. In general, they are carried out in a range of from -20 to 200°C, preferably from 0 to 100°C, and more preferably from 25 to 50°C. The steps of this reaction are generally carried out under atmospheric pressure. However, it is also possible to carry them out under superatmospheric pressure or under reduced pressure (for example, in a range of from 0.5 to 5 bar). The reaction time can generally be varied within a relatively wide range. In general, the reaction is finished after a period of from 2 to 24 hours, preferably from 6 to 12 hours.

Synthetic transformations that may be employed in the synthesis of compounds of Formula I and in the synthesis of intermediates involved in the synthesis of compounds of Formula I are known by or accessible to one skilled in the art. Collections of synthetic transformations may be found in compilations, such as:

- J. March. *Advanced Organic Chemistry*, 4th ed.; John Wiley: New York (1992)

- R.C. Larock. *Comprehensive Organic Transformations*, 2nd ed.; Wiley-VCH: New York (1999)
- F.A. Carey; R.J. Sundberg. *Advanced Organic Chemistry*, 2nd ed.; Plenum Press: New York (1984)
- T.W. Greene; P.G.M. Wuts. *Protective Groups in Organic Synthesis*, 3rd ed.; John Wiley: New York (1999)
- L.S. Hegedus. *Transition Metals in the Synthesis of Complex Organic Molecules*, 2nd ed.; University Science Books: Mill Valley, CA (1994)
- L.A. Paquette, Ed. *The Encyclopedia of Reagents for Organic Synthesis*; John Wiley: New York (1994)
- A.R. Katritzky; O. Meth-Cohn; C.W. Rees, Eds. *Comprehensive Organic Functional Group Transformations*; Pergamon Press: Oxford, UK (1995)
- G. Wilkinson; F.G A. Stone; E.W. Abel, Eds. *Comprehensive Organometallic Chemistry;* Pergamon Press: Oxford, UK (1982)
- B.M. Trost; I. Fleming. *Comprehensive Organic Synthesis*; Pergamon Press: Oxford, UK (1991)
- A.R. Katritzky; C.W. Rees Eds. *Comprehensive Heterocylic Chemistry*; Pergamon Press: Oxford, UK (1984)
- A.R. Katritzky; C.W. Rees; E.F.V. Scriven, Eds. *Comprehensive Heterocylic Chemistry II*; Pergamon Press: Oxford, UK (1996)
- C. Hansch; P.G. Sammes; J.B. Taylor, Eds. *Comprehensive Medicinal Chemistry*: Pergamon Press: Oxford, UK (1990).

In addition, recurring reviews of synthetic methodology and related topics include *Organic Reactions*; John Wiley: New York; *Organic Syntheses*; John Wiley: New York; *Reagents for Organic Synthesis*: John Wiley: New York; *The Total Synthesis of Natural Products*; John Wiley: New York; *The Organic Chemistry of Drug Synthesis*; John Wiley: New York; *Annual Reports in Organic Synthesis*; Academic Press: San Diego CA; and *Methoden der Organischen Chemie* (Houben-Weyl); Thieme: Stuttgart, Germany. Furthermore, databases of synthetic transformations include *Chemical Abstracts*, which may be searched using either CAS OnLine or SciFinder, *Handbuch der Organischen Chemie* (Beilstein), which may be searched using SpotFire, and REACCS.

The compounds may be administered orally, topically, parenterally, by inhalation or spray or rectally in dosage unit formulations. The term 'administration by injection' includes intravenous, intramuscular, subcutaneous and parenteral injections, as well as use of infusion techniques. One or more compounds may be present in association with one or more non-toxic pharmaceutically acceptable carriers and if desired other active ingredients.

Compositions intended for oral use may be prepared according to any suitable method known to the art for the manufacture of pharmaceutical compositions. Such compositions may contain one or more agents selected from the group consisting of diluents, sweetening agents, flavoring agents, coloring agents and preserving agents in order to provide palatable preparations. Tablets contain the active ingredient in admixture with non-toxic pharmaceutically acceptable excipients that are suitable for the manufacture of tablets. These excipients may be, for example, inert diluents, such as calcium carbonate, sodium carbonate, lactose, calcium phosphate or sodium phosphate; granulating and disintegrating agents, for example, corn starch, or alginic acid; and binding agents, for example magnesium stearate, stearic acid or talc. The tablets may be uncoated or they may be coated by known techniques to delay disintegration and adsorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or glyceryl distearate may be employed. These compounds may also be prepared in solid, rapidly released form.

Formulations for oral use may also be presented as hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate or kaolin, or as soft gelatin capsules wherein the active ingredient is mixed with water or an oil medium, for example peanut oil, liquid paraffin or olive oil.

Aqueous suspensions contain the active materials in admixture with excipients suitable for the manufacture of aqueous suspensions. Such excipients are suspending agents, for example sodium carboxymethylcellulose, methylcellulose, hydroxypropyl methylcellulose, sodium alginate, polyvinylpyrrolidone, gum tragacanth and gum acacia; dispersing or wetting agents may be a naturally occurring phosphatide, for example, lecithin, or condensation products or an alkylene oxide with fatty acids, for example polyoxyethylene stearate, or condensation products of ethylene oxide with long chain aliphatic alcohols, for example heptadecaethylene oxycetanol, or

condensation products of ethylene oxide with partial esters derived from fatty acids and hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with partial esters derived from fatty acids and hexitol anhydrides, for example polyethylene sorbitan monooleate. The aqueous suspensions may also contain one or more preservatives, for example ethyl, or n-propyl *p*-hydroxybenzoate, one or more coloring agents, one or more flavoring agents, and one or more sweetening agents, such as sucrose or saccharin.

Dispersible powders and granules suitable for preparation of an aqueous suspension by the addition of water provide the active ingredient in admixture with a dispersing or wetting agent, suspending agent and one or more preservatives. Suitable dispersing or wetting agents and suspending agents are exemplified by those already mentioned above. Additional excipients, for example, sweetening, flavoring and coloring agents, may also be present.

The compounds may also be in the form of non-aqueous liquid formulations, e.g., oily suspensions which may be formulated by suspending the active ingredients in a vegetable oil, for example arachis oil, olive oil, sesame oil or peanut oil, or in a mineral oil such as liquid paraffin. The oily suspensions may contain a thickening agent, for example beeswax, hard paraffin or cetyl alcohol. Sweetening agents such as those set forth above, and flavoring agents may be added to provide palatable oral preparations. These compositions may be preserved by the addition of an anti-oxidant such as ascorbic acid.

Pharmaceutical compositions of the invention may also be in the form of oil-in-water emulsions. The oily phase may be a vegetable oil, for example olive oil or arachis oil, or a mineral oil, for example liquid paraffin or mixtures of these. Suitable emulsifying agents may be naturally-occurring gums, for example gum acacia or gum tragacanth, naturally-occurring phosphatides, for example soy bean, lecithin, and esters or partial esters derived from fatty acids and hexitol anhydrides, for example sorbitan monooleate, and condensation products of the said partial esters with ethylene oxide, for example polyoxyethylene sorbitan monooleate. The emulsions may also contain sweetening and flavoring agents.

Syrups and elixirs may be formulated with sweetening agents, for example glycerol, propylene glycol, sorbitol or sucrose. Such formulations may also contain a demulcent, a preservative and flavoring and coloring agents.

The compounds may also be administered in the form of suppositories for rectal administration of the drug. These compositions can be prepared by mixing the drug with a suitable non-irritating excipient which is solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum to release the drug. Such materials include cocoa butter and polyethylene glycols.

The compounds of this invention may also be administered parenterally, that is, subcutaneously, intravenously, intraocularly, intrasynovially, intramuscularly, or interperitoneally, as injectable dosages of the compound in a physiologically acceptable diluent with a pharmaceutical carrier which can be a sterile liquid or mixture of liquids such as water, saline, aqueous dextrose and related sugar solutions, an alcohol such as ethanol, isopropanol, or hexadecyl alcohol, glycols such as propylene glycol or polyethylene glycol, glycerol ketals such as 2,2-dimethyl-1,1-dioxolane-4-methanol, ethers such as poly(ethylene glycol) 400, an oil, a fatty acid, a fatty acid ester or, a fatty acid glyceride, or an acetylated fatty acid glyceride, with or without the addition of a pharmaceutically acceptable surfactant such as a soap or a detergent, suspending agent such as pectin, carbomers, methycellulose, hydroxypropylmethylcellulose, or carboxymethylcellulose, or emulsifying agent and other pharmaceutical adjuvants.

Illustrative of oils which can be used in the parenteral formulations of this invention are those of petroleum, animal, vegetable, or synthetic origin, for example, peanut oil, soybean oil, sesame oil, cottonseed oil, corn oil, olive oil, petrolatum and mineral oil. Suitable fatty acids include oleic acid, stearic acid, isostearic acid and myristic acid. Suitable fatty acid esters are, for example, ethyl oleate and isopropyl myristate. Suitable soaps include fatty acid alkali metal, ammonium, and triethanolamine salts and suitable detergents include cationic detergents, for example dimethyl dialkyl ammonium halides, alkyl pyridinium halides, and alkylamine acetates; anionic detergents, for example, alkyl, aryl, and olefin sulfonates, alkyl, olefin, ether, and monoglyceride sulfates, and sulfosuccinates; non-ionic detergents, for example, fatty amine oxides, fatty acid alkanolamides, and poly(oxyethylene-oxypropylene)s or ethylene oxide or propylene oxide copolymers; and amphoteric detergents, for example, alkyl beta-aminopropionates, and 2-alkylimidazoline quarternary ammonium salts, as well as mixtures.

The parenteral compositions of this invention will typically contain from about 0.5% to about 25% by weight of the active ingredient in solution. Preservatives and

buffers may also be used advantageously. In order to minimize or eliminate irritation at the site of injection, such compositions may contain a non-ionic surfactant having a hydrophile-lipophile balance (HLB) of from about 12 to about 17. The quantity of surfactant in such formulation ranges from about 5% to about 15% by weight. The surfactant can be a single component having the above HLB or can be a mixture of two or more components having the desired HLB.

Illustrative of surfactants used in parenteral formulations are the class of polyethylene sorbitan fatty acid esters, for example, sorbitan monooleate and the high molecular weight adducts of ethylene oxide with a hydrophobic base, formed by the condensation of propylene oxide with propylene glycol.

The pharmaceutical compositions may be in the form of sterile injectable aqueous suspensions. Such suspensions may be formulated according to known methods using suitable dispersing or wetting agents and suspending agents such as, for example, sodium carboxymethylcellulose, methylcellulose, hydroxypropylmethylcellulose, sodium alginate, polyvinylpyrrolidone, gum tragacanth and gum acacia; dispersing or wetting agents which may be a naturally occurring phosphatide such as lecithin, a condensation product of an alkylene oxide with a fatty acid, for example, polyoxyethylene stearate, a condensation product of ethylene oxide with a long chain aliphatic alcohol, for example, heptadeca-ethyleneoxycetanol, a condensation product of ethylene oxide with a partial ester derived form a fatty acid and a hexitol such as polyoxyethylene sorbitol monooleate, or a condensation product of an ethylene oxide with a partial ester derived from a fatty acid and a hexitol anhydride, for example polyoxyethylene sorbitan monooleate.

The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally acceptable diluent or solvent. Diluents and solvents that may be employed are, for example, water, Ringer's solution, isotonic sodium chloride solutions and isotonic glucose solutions. In addition, sterile fixed oils are conventionally employed as solvents or suspending media. For this purpose, any bland, fixed oil may be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid can be used in the preparation of injectables.

Compounds of the invention may also be administrated transdermally using methods ("patches") known to those skilled in the art (see, for example: Chien; "Transdermal Controlled Systemic Medications"; Marcel Dekker, Inc.; 1987. Lipp et al. WO94/04157). Such transdermal patches may be used to provide continuous or

discontinuous infusion of the compounds of the present invention in controlled amounts. The construction and use of transdermal patches for the delivery of pharmaceutical agents is well known in the art (see, e.g., US Patent 5,023,252, issued June 11, 1991, incorporated herein by reference). Such patches may be constructed for continuous, pulsatile, or on demand delivery of pharmaceutical agents. For example, a solution or suspension of a compound of Formula I in a suitable volatile solvent optionally containing penetration enhancing agents can be combined with additional additives known to those skilled in the art, such as matrix materials and bacteriocides. After sterilization, the resulting mixture can be formulated following known procedures into dosage forms. In addition, on treatment with emulsifying agents and water, a solution or suspension of a compound of Formula I may be formulated into a lotion or salve.

Suitable solvents for processing transdermal delivery systems are known to those skilled in the art, and include lower alcohols such as ethanol or isopropyl alcohol, lower ketones such as acetone, lower carboxylic acid esters such as ethyl acetate, polar ethers such as tetrahydrofuran, lower hydrocarbons such as hexane, cyclohexane or benzene, or halogenated hydrocarbons such as dichloromethane, chloroform, trichlorotrifluoroethane, or trichlorofluoroethane. Suitable solvents may also include mixtures of one or more materials selected from lower alcohols, lower ketones, lower carboxylic acid esters, polar ethers, lower hydrocarbons, halogenated hydrocarbons.

Suitable penetration enhancing materials for transdermal delivery system are known to those skilled in the art, and include, for example, monohydroxy or polyhydroxy alcohols such as ethanol, propylene glycol or benzyl alcohol, saturated or unsaturated C_8–C_{18} fatty alcohols such as lauryl alcohol or cetyl alcohol, saturated or unsaturated C_8–C_{18} fatty acids such as stearic acid, saturated or unsaturated fatty esters with up to 24 carbons such as methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl isobutyl tert-butyl or monoglycerin esters of acetic acid, capronic acid, lauric acid, myristinic acid, stearic acid, or palmitic acid, or diesters of saturated or unsaturated dicarboxylic acids with a total of up to 24 carbons such as diisopropyl adipate, diisobutyl adipate, diisopropyl sebacate, diisopropyl maleate, or diisopropyl fumarate. Additional penetration enhancing materials include phosphatidyl derivatives such as lecithin or cephalin, terpenes, amides, ketones, ureas and their derivatives, and ethers such as dimethyl isosorbid and diethyleneglycol monoethyl

ether. Suitable penetration enhancing formulations may also include mixtures of one or more materials selected from monohydroxy or polyhydroxy alcohols, saturated or unsaturated C_8–C_{18} fatty alcohols, saturated or unsaturated C_8–C_{18} fatty acids, saturated or unsaturated fatty esters with up to 24 carbons, diesters of saturated or unsaturated discarboxylic acids with a total of up to 24 carbons, phosphatidyl derivatives, terpenes, amides, ketones, ureas and their derivatives, and ethers.

Suitable binding materials for transdermal delivery systems are known to those skilled in the art and include polyacrylates, silicones, polyurethanes, block polymers, styrenebutadiene copolymers, and natural and synthetic rubbers. Cellulose ethers, derivatized polyethylenes, and silicates may also be used as matrix components. Additional additives, such as viscous resins or oils may be added to increase the viscosity of the matrix.

Controlled release formulations for parenteral administration include liposomal, polymeric microsphere and polymeric gel formulations, which are known in the art.

It may be desirable or necessary to introduce the pharmaceutical composition to the patient via a mechanical delivery device. The construction and use of mechanical delivery devices for the delivery of pharmaceutical agents is well known in the art. Direct techniques for, for example, administering a drug directly to the brain usually involve placement of a drug delivery catheter into the patient's ventricular system to bypass the blood-brain barrier. One such implantable delivery system, used for the transport of agents to specific anatomical regions of the body, is described in U.S. Pat. No. 5,011,472.

The compositions of the invention can also contain other conventional pharmaceutically acceptable compounding ingredients, generally referred to as carriers or diluents, as necessary or desired. Conventional procedures for preparing such compositions in appropriate dosage forms can be utilized. Such ingredients and procedures include those described in the following references, each of which is incorporated herein by reference: Powell, M.F. *et al,* "Compendium of Excipients for Parenteral Formulations" *PDA J. Pharmaceut. Sci. Tech.* **1998**, 52(5), 238-311; Strickley, R.G "Parenteral Formulations of Small Molecule Therapeutics Marketed in the United States (1999)-Part-1" *PDA J. Pharmaceut. Sci. Tech.* **1999**, 53(6), 324-349; and Nema, S. *et al,* "Excipients and Their Use in Injectable Products" *PDA J. Pharmaceut. Sci. Tech.* **1997**, 51(4), 166-171.

This invention also relates to administering pharmaceutical compositions containing one or more compounds of the present invention. These compositions can be utilized to achieve the desired pharmacological effect by administration to a patient in need thereof. A patient, for the purpose of this invention, is a mammal, including a human, in need of treatment for the particular condition or disease. Therefore, the present invention includes pharmaceutical compositions which are comprised of a pharmaceutically acceptable carrier and a pharmaceutically effective amount of a compound, or salt thereof, of the present invention. A pharmaceutically acceptable carrier is any carrier which is relatively non-toxic and innocuous to a patient at concentrations consistent with effective activity of the active ingredient so that any side effects ascribable to the carrier do not vitiate the beneficial effects of the active ingredient. A pharmaceutically effective amount of compound is that amount which produces a result or exerts an influence on the particular condition being treated. The compounds of the present invention can be administered with pharmaceutically-acceptable carriers well known in the art using any effective conventional dosage unit forms, including immediate, slow and timed release preparations, orally, parenterally, topically, nasally, ophthalmically, otically, sublingually, rectally, vaginally, and the like.

For oral administration, the compounds can be formulated into solid or liquid preparations such as capsules, pills, tablets, troches, lozenges, melts, powders, solutions, suspensions, or emulsions, and may be prepared according to methods known to the art for the manufacture of pharmaceutical compositions. The solid unit dosage forms can be a capsule which can be of the ordinary hard- or soft-shelled gelatin type containing, for example, surfactants, lubricants, and inert fillers such as lactose, sucrose, calcium phosphate, and corn starch.

In another embodiment, the compounds of this invention may be tableted with conventional tablet bases such as lactose, sucrose and cornstarch in combination with binders such as acacia, corn starch or gelatin, disintegrating agents intended to assist the break-up and dissolution of the tablet following administration such as potato starch, alginic acid, corn starch, and guar gum, gum tragacanth, acacia, lubricants intended to improve the flow of tablet granulation and to prevent the adhesion of tablet material to the surfaces of the tablet dies and punches, for example talc, stearic acid, or magnesium, calcium or zinc stearate, dyes, coloring agents, and flavoring agents such as peppermint, oil of wintergreen, or cherry flavoring, intended to

enhance the aesthetic qualities of the tablets and make them more acceptable to the patient. Suitable excipients for use in oral liquid dosage forms include dicalcium phosphate and diluents such as water and alcohols, for example, ethanol, benzyl alcohol, and polyethylene alcohols, either with or without the addition of a pharmaceutically acceptable surfactant, suspending agent or emulsifying agent.

Various other materials may be present as coatings or to otherwise modify the physical form of the dosage unit. For instance tablets, pills or capsules may be coated with shellac, sugar or both.

Commonly used pharmaceutical ingredients which can be used as appropriate to formulate the composition for its intended route of administration include:

acidifying agents (examples include but are not limited to acetic acid, citric acid, fumaric acid, hydrochloric acid, nitric acid);

alkalinizing agents (examples include but are not limited to ammonia solution, ammonium carbonate, diethanolamine, monoethanolamine, potassium hydroxide, sodium borate, sodium carbonate, sodium hydroxide, triethanolamine, trolamine);

adsorbents (examples include but are not limited to powdered cellulose and activated charcoal);

aerosol propellants (examples include but are not limited to carbon dioxide, CCl_2F_2, $F_2ClC\text{-}CClF_2$ and $CClF_3$)

air displacement agents (examples include but are not limited to nitrogen and argon);

antifungal preservatives (examples include but are not limited to benzoic acid, butylparaben, ethylparaben, methylparaben, propylparaben, sodium benzoate);

antimicrobial preservatives (examples include but are not limited to benzalkonium chloride, benzethonium chloride, benzyl alcohol, cetylpyridinium chloride, chlorobutanol, phenol, phenylethyl alcohol, phenylmercuric nitrate and thimerosal);

antioxidants (examples include but are not limited to ascorbic acid, ascorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, hypophosphorus acid, monothioglycerol, propyl gallate, sodium ascorbate, sodium bisulfite, sodium formaldehyde sulfoxylate, sodium metabisulfite);

binding materials (examples include but are not limited to block polymers, natural and synthetic rubber, polyacrylates, polyurethanes, silicones, polysiloxanes and styrene-butadiene copolymers);

buffering agents (examples include but are not limited to potassium metaphosphate, dipotassium phosphate, sodium acetate, sodium citrate anhydrous and sodium citrate dihydrate)

carrying agents (examples include but are not limited to acacia syrup, aromatic syrup, aromatic elixir, cherry syrup, cocoa syrup, orange syrup, syrup, corn oil, mineral oil, peanut oil, sesame oil, bacteriostatic sodium chloride injection and bacteriostatic water for injection)

chelating agents (examples include but are not limited to edetate disodium and edetic acid)

colorants (examples include but are not limited to FD&C Red No. 3, FD&C Red No. 20, FD&C Yellow No. 6, FD&C Blue No. 2, D&C Green No. 5, D&C Orange No. 5, D&C Red No. 8, caramel and ferric oxide red);

clarifying agents (examples include but are not limited to bentonite);

emulsifying agents (examples include but are not limited to acacia, cetomacrogol, cetyl alcohol, glyceryl monostearate, lecithin, sorbitan monooleate, polyoxyethylene 50 monostearate);

encapsulating agents (examples include but are not limited to gelatin and cellulose acetate phthalate)

flavorants (examples include but are not limited to anise oil, cinnamon oil, cocoa, menthol, orange oil, peppermint oil and vanillin);

humectants (examples include but are not limited to glycerol, propylene glycol and sorbitol);

levigating agents (examples include but are not limited to mineral oil and glycerin);

oils (examples include but are not limited to arachis oil, mineral oil, olive oil, peanut oil, sesame oil and vegetable oil);

ointment bases (examples include but are not limited to lanolin, hydrophilic ointment, polyethylene glycol ointment, petrolatum, hydrophilic petrolatum, white ointment, yellow ointment, and rose water ointment);

penetration enhancers (transdermal delivery) (examples include but are not limited to monohydroxy or polyhydroxy alcohols, mono-or polyvalent alcohols,

saturated or unsaturated fatty alcohols, saturated or unsaturated fatty esters, saturated or unsaturated dicarboxylic acids, essential oils, phosphatidyl derivatives, cephalin, terpenes, amides, ethers, ketones and ureas)

plasticizers (examples include but are not limited to diethyl phthalate and glycerol);

solvents (examples include but are not limited to ethanol, corn oil, cottonseed oil, glycerol, isopropanol, mineral oil, oleic acid, peanut oil, purified water, water for injection, sterile water for injection and sterile water for irrigation);

stiffening agents (examples include but are not limited to cetyl alcohol, cetyl esters wax, microcrystalline wax, paraffin, stearyl alcohol, white wax and yellow wax);

suppository bases (examples include but are not limited to cocoa butter and polyethylene glycols (mixtures));

surfactants (examples include but are not limited to benzalkonium chloride, nonoxynol 10, oxtoxynol 9, polysorbate 80, sodium lauryl sulfate and sorbitan mono-palmitate);

suspending agents (examples include but are not limited to agar, bentonite, carbomers, carboxymethylcellulose sodium, hydroxyethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, kaolin, methylcellulose, tragacanth and veegum);

sweetening agents (examples include but are not limited to aspartame, dextrose, glycerol, mannitol, propylene glycol, saccharin sodium, sorbitol and sucrose);

tablet anti-adherents (examples include but are not limited to magnesium stearate and talc);

tablet binders (examples include but are not limited to acacia, alginic acid, carboxymethylcellulose sodium, compressible sugar, ethylcellulose, gelatin, liquid glucose, methylcellulose, non-crosslinked polyvinyl pyrrolidone, and pregelatinized starch);

tablet and capsule diluents (examples include but are not limited to dibasic calcium phosphate, kaolin, lactose, mannitol, microcrystalline cellulose, powdered cellulose, precipitated calcium carbonate, sodium carbonate, sodium phosphate, sorbitol and starch);

tablet coating agents (examples include but are not limited to liquid glucose, hydroxyethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, methylcellulose, ethylcellulose, cellulose acetate phthalate and shellac);

tablet direct compression excipients (examples include but are not limited to dibasic calcium phosphate);

tablet disintegrants (examples include but are not limited to alginic acid, carboxymethylcellulose calcium, microcrystalline cellulose, polacrillin potassium, cross-linked polyvinylpyrrolidone, sodium alginate, sodium starch glycollate and starch);

tablet glidants (examples include but are not limited to colloidal silica, corn starch and talc);

tablet lubricants (examples include but are not limited to calcium stearate, magnesium stearate, mineral oil, stearic acid and zinc stearate);

tablet/capsule opaquants (examples include but are not limited to titanium dioxide);

tablet polishing agents (examples include but are not limited to carnauba wax and white wax);

thickening agents (examples include but are not limited to beeswax, cetyl alcohol and paraffin);

tonicity agents (examples include but are not limited to dextrose and sodium chloride);

viscosity increasing agents (examples include but are not limited to alginic acid, bentonite, carbomers, carboxymethylcellulose sodium, methylcellulose, polyvinyl pyrrolidone, sodium alginate and tragacanth); and

wetting agents (examples include but are not limited to heptadecaethylene oxycetanol, lecithins, sorbitol monooleate, polyoxyethylene sorbitol monooleate, and polyoxyethylene stearate).

The total amount of the active ingredient to be administered will generally range from about 0.001 mg/kg to about 200 mg/kg, and preferably from about 0.01 mg/kg to about 20 mg/kg body weight per day. A unit dosage may contain from about 0.5 mg to about 1500 mg of active ingredient, and can be administered one or more times per day. For all regimens of use disclosed herein for compounds of Formula I, the daily oral dosage regimen will preferably be from 0.01 to 200 mg/Kg of total body weight. The daily dosage for administration by injection, including

intravenous, intramuscular, subcutaneous and parenteral injections, and use of infusion techniques will preferably be from 0.01 to 200 mg/Kg of total body weight. The daily rectal dosage regime will preferably be from 0.01 to 200 mg/Kg of total body weight. The daily vaginal dosage regime will preferably be from 0.01 to 200 mg/Kg of total body weight. The daily topical dosage regime will preferably be from 0.1 to 200 mg administered between one to four times daily. The transdermal concentration will preferably be that required to maintain a daily dose of from 0.01 to 200 mg/Kg. The daily inhalation dosage regime will preferably be from 0.01 to 100 mg/Kg of total body weight. These dosages regimes can be achieved with multiple dosages within a single day or extended dosages, such as those given on a weekly or monthly basis.

Based upon standard laboratory techniques known to evaluate compounds, by standard toxicity tests and by standard pharmacological assays for the determination of treatment of the conditions identified above in mammals, and by comparison of these results with the results of known medicaments that are used to treat these conditions, the effective dosage of the compounds of this invention can readily be determined for treatment of each desired indication. The amount of the active ingredient to be administered in the treatment of one of these conditions can vary widely according to such considerations as the particular compound and dosage unit employed, the mode of administration, the period of treatment, the age and gender of the patient treated, and the nature and extent of the condition treated.

It will be appreciated by those skilled in the art that the particular method of administration will depend on a variety of factors, all of which are considered routinely when administering therapeutics. It will also be appreciated by one skilled in the art that the specific dose level for a given patient depends on a variety of factors, including specific activity of the compound administered, age, body weight, health, sex, diet, time and route of administration, rate of excretion, etc. It will be further appreciated by one skilled in the art that the optimal course of treatment, i.e., the mode of treatment and the daily number of doses of a compound of Formula I or a pharmaceutically acceptable salt thereof given for a defined number of days, can be ascertained by those skilled in the art using conventional treatment tests.

It will be understood, however, that the specific dose level for any particular patient will depend upon a variety of factors, including the activity of the specific compound employed, the age, body weight, general health, sex, diet, time of

administration, route of administration, and rate of excretion, drug combination and the severity of the condition undergoing therapy.

It will be further appreciated by one skilled in the art that the optimal course of treatment, i.e., the mode of treatment and the daily number of doses of a compound of this invention given for a defined number of days, can be ascertained by those skilled in the art using conventional treatment tests.

Dosages and compound efficacy can also be determined routinely using in vitro and in vivo animal models. For example, murine models have been developed using mice deficent in apolipoprotein E (Leidenfrost et al., Am. J. Pathol., 163:773-778, 2003). See, also Bayes-Genis et al, Curr. Intv. Cardio. Rep., 2:303-308, 200, for reviews of rat, rabbit, canine, baboon, and procine models.

Pharmaceutical compositions according to the present invention can be illustrated as follows:

Sterile IV Solution: A 5 mg/ml solution of the desired compound of this invention is made using sterile, injectable water, and the pH is adjusted if necessary. The solution is diluted for administration to 1 – 2 mg/ml with sterile 5% dextrose and is administered as an IV infusion over 60 minutes.

Lyophilized powder for IV administration: A sterile preparation can be prepared with (i) 100 - 1000 mg of the desired compound of this invention as a lyophilized powder, (ii) 32- 327 mg/ml sodium citrate, and (iii) 300 – 3000 mg Dextran 40. The formulation is reconstituted with sterile, injectable saline or dextrose 5% to a concentration of 10 to 20 mg/ml, which is further diluted with saline or dextrose 5% to 0.2 – 0.4 mg/ml, and is administered either IV bolus or by IV infusion over 15 – 60 minutes.

Intramuscular suspension: The following solution or suspension can be prepared, for intramuscular injection:

50 mg/ml of the desired, water-insoluble compound of this invention
5 mg/ml sodium carboxymethylcellulose
4 mg/ml TWEEN 80
9 mg/ml sodium chloride
9 mg/ml benzyl alcohol

Hard Shell Capsules: A large number of unit capsules are prepared by filling standard two-piece hard galantine capsules each with 100 mg of powdered active ingredient, 150 mg of lactose, 50 mg of cellulose and 6 mg of magnesium stearate.

Soft Gelatin Capsules: A mixture of active ingredient in a digestible oil such as soybean oil, cottonseed oil or olive oil is prepared and injected by means of a positive displacement pump into molten gelatin to form soft gelatin capsules containing 100 mg of the active ingredient. The capsules are washed and dried. The active ingredient can be dissolved in a mixture of polyethylene glycol, glycerin and sorbitol to prepare a water miscible medicine mix.

Tablets: A large number of tablets are prepared by conventional procedures so that the dosage unit was 100 mg of active ingredient, 0.2 mg. of colloidal silicon dioxide, 5 mg of magnesium stearate, 275 mg of microcrystalline cellulose, 11 mg. of starch, and 98.8 mg of lactose. Appropriate aqueous and non-aqueous coatings may be applied to increase palatability, improve elegance and stability or delay absorption.

Immediate Release Tablets/Capsules: These are solid oral dosage forms made by conventional and novel processes. These units are taken orally without water for immediate dissolution and delivery of the medication. The active ingredient is mixed in a liquid containing ingredient such as sugar, gelatin, pectin and sweeteners. These liquids are solidified into solid tablets or caplets by freeze drying and solid state extraction techniques. The drug compounds may be compressed with viscoelastic and thermoelastic sugars and polymers or effervescent components to produce porous matrices intended for immediate release, without the need of water.

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever. The entire disclosure of all applications, patents and publications, cited above and in the figures are hereby incorporated by reference in their entirety, U.S. Provisional Application Nos. 60/556,062, filed March 25, 2004, 60/520,399, filed November 17, 2003, and 60/471,735, filed May 20, 2003, each of which are hereby incorporated by reference in their entirety.

EXAMPLES

Murine PDGFR FRET biochemical assay

This assay was formatted in a 96-well black plate (Costar 3915). The following reagents (and their sources) are used: Europium-labeled anti-phosphotyrosine antibody pY20 and streptavidin-APC; poly GT-biotin, and mouse PDGFR within DRT. The reaction conditions are as follows: 1 nM mouse PDGFR is combined with 20 μM ATP, 7nM poly GT-biotin, 1 nM pY20 antibody, 5 nM streptavidin-APC, and 1% DMSO in assay buffer (50 mM HEPES pH 7.5, 10 mM $MgCl_2$, 0.1 mM EDTA, 0.015% BRIJ 35, 0.1 mg/mL BSA, 0.1% mercaptoethanol). Reaction is initiated upon addition of enzyme. Final reaction volume in each well is 100 μL. After 90 minutes, the reaction is stopped by addition of 10 μL/well of 5 μM staurosporine. Plates are read at both 615 and 665 nm on a Perkin Elmer VictorV Multilabel counter at about 1 hour after the reaction is stopped. Signal is calculated as a ratio: (665 nm / 615 nm) * 10000 for each well.

For IC_{50} generation for PDGFR beta, compounds were added prior to the enzyme initiation. A 50-fold stock plate was made with compounds serially diluted 1:3 in a 50% DMSO/50% dH2O solution. A 2 μL addition of the stock to the assay gave final compound concentrations ranging from 10 μM – 4.56 nM in 1% DMSO. The data were expressed as percent inhibition: % inhibition = 100-((Signal with inhibitor-background)/(Signal without inhibitor - background)) * 100

The following compounds show an IC_{50} of less than 10 micromolar in this biochemical assay, which represents a marked inhibition of PDGFR:

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-carbamoyl-4-pyridyloxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-carbamoyl-4-pyridyl oxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-fluoro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea,

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-*N*'-(4-(2-cyano-4-pyridyloxy) phenyl) urea, and

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-*N*'-(4-(2-cyano-4-pyridyloxy)-2-fluorophenyl) urea.

pPDGFR-beta sandwich ELISA in AoSMC cells

100K P3-P6 Aortic SMC were plated in each well of 12-well cluster in 1000 uL volume/ well of SGM-2 using standard cell culture techniques. Next day, cells were rinsed with 1000 uL D-PBS (Gibco) once, then serum starved in 500 uL SBM (smooth muscle cell basal media) with 0.1% BSA (Sigma, Cat A9576) overnight. Compounds were diluted at a dose range from (10 uM to 1 nM in 10-fold dilution steps in DMSO. Final DMSO concentration 0.1%). Remove old media by inversion into the sink quickly then add 100 ul of each dilution to corresponding well of cells for 1 hr at 37 ^{0}C. Cells were then stimulated with 10 ng/mL PDGF BB ligand for 7 minutes at 37 ^{0}C. The media is decanted and 150 uL of isotonic lysis buffer with protease inhibitor tablet (Complete; EDTA-free) and 0.2 mM Na vanadate is added. Cells are lysed for 15 min at 4 ^{0}C on shaker in cold room. Lysates are put in eppendorf tubes to which 15 uL of agarose-conjugated anti-PDGFR-b antibody is added (Santa Cruz, sc-339) and incubated at 4 ^{0}C overnight. Next day, beads are rinsed in 50-volumes of PBS three times and boiled in 1x LDS sample buffer (Invitrogen) for 5 minutes. Samples were run on 3-8% gradient Tris-Acetate gels (Invitrogen) and transferred onto Nitrocellulose. Membranes were blocked in 1% BSA/TBS-T for 1 hr. before incubation in anti-phospho-PDGFR-b (Tyr-857) antibody in blocking buffer (1:1000 dilution) for 1 hour. After three washes in TBS-T,

membranes were incubated in Goat anti-rabbit HRP IgG (Amersham, 1:25000 dilution) for 1 hr. Three more washes followed before addition of ECL substrate. Membranes were exposed to Hyperfilm-ECL. Subsequently, membranes were stripped and reprobed with anti-PDGFR-beta antibody (Santa Cruz, SC-339) for total PDGFR-beta.

The following compounds show an IC_{50} of less than 10 micromolar in this bioassay of PDGFR inhibition in cells:

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,

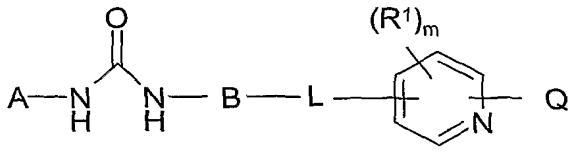
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea, and

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(*N*-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea.

Claims:

1. A method for treating or preventing a disease or condition in mammal, or a mammalian cell thereof, which is mediated by platelet-derived growth factor receptor-beta, comprising:

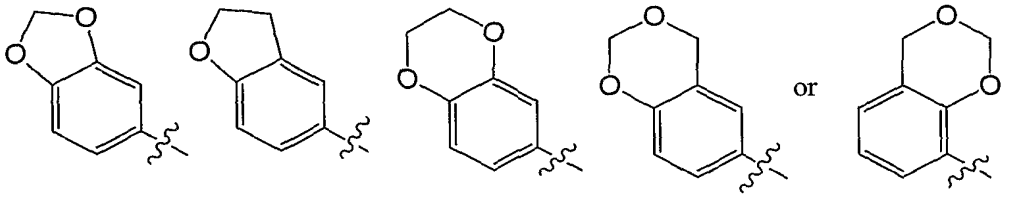
administering to a subject in need thereof, an effective amount of an aryl urea compound of formula I, a salt form of a compound of Formula I, an isolated or mixed stereoisomer of a compound of Formula I, an ester of a compound of formula I, a metabolite of a compound of formula I, or a prodrug of a compound of Formula I,



(I)

wherein:

A is phenyl, optionally substituted 1, 2 or 3 times by R^3, wherein each R^3 is independently C_1-C_5 alkyl, C_1-C_5 haloalkyl, up to per-haloalkyl, C_1-C_5 alkoxy, C_1-C_5 haloalkoxy, up to per-haloalkoxy, halogen, cyano, or nitro; or A is a group of the formula:



optionally substituted 1, 2, 3, 4, 5 or 6 times with R^4 wherein each R^4 is independently C_1-C_5 alkyl or halogen;

B is phenylene, optionally substituted 1, 2 or 3 times by R^2, or naphthylene, optionally substituted optionally substituted 1, 2 or 3 times by R^2, wherein each R^2 is independently C_1-C_5 alkyl, C_1-C_5 haloalkyl, up to per-haloalkyl, C_1-C_5 alkoxy, C_1-C_5 haloalkoxy up to per-haloalkoxyl, halogen, cyano or nitro;

Q is cyano, -C(O)-R^a, or -C(O)-NR^bR^c, where each R^a, R^b and R^c is independently H or C_1-C_5 alkyl,

L is -O- or -S-,

m is an integer 0,1,2 or 3, and

each R^1 is independently halogen, C_{1-5} alkyl, C_{1-5} haloalkyl, up to per-haloalkyl, C_{1-5} alkoxy, C_{1-5} haloalkoxy, up to per-haloalkoxy, N-oxo or N-hydroxy.

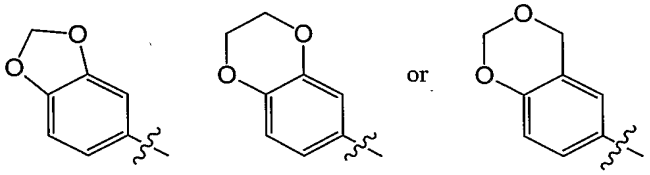
2. A method of claim 1 wherein for the compound of formula (I), each R^2 is independently fluorine, chorine, bromine, methyl, ethyl, propyl, butyl, isopropyl, tert-butyl, trifluoromethyl, methoxy, CN or NO_2.

3. A method of claims 1 or 2 wherein for the compound of formula (I), each R^3 is independently fluorine, chorine, bromine, methyl, ethyl, propyl, butyl, pentyl, isopropyl, iso-butyl, sec-butyl, tert-butyl, trifluoromethyl, methoxy, ethoxy, trifluoromethoxy, CN or NO_2 and each R^4 is independently fluorine, chorine, bromine or methyl.

4. A method of any of claims 1-3 wherein for the compound of formula (I), each R^1 is independently methyl, ethyl, propyl, oxygen, cyano, n-oxo or n-hydroxy and each R^a, R^b and R^c is independently H or methyl.

5. A method of claims 1-4 wherein for the compound of formula (I), A is substituted phenyl.

6. A method of any of claims 1-4 wherein for the compound of formula (I), A is a group of the formula:



optionally substituted 1, 2, 3 or 4 times with R^4, wherein each R^4 is independently chlorine or fluorine.

7. A method of any of claims 1-6 wherein for the compound of formula (I), B is phenylene.

8. A method of anyof claims 1-6 wherein for the compound of formula (I), B is naphthylene.

9. A method of any of claims 1-6 wherein for the compound of formula (I), B is phenylene substituted by at least one fluorine atom.

10. A method of any of claims 1-9 wherein for the compound of formula (I), L is oxygen.

11. A method of any of claims 1-10 wherein for the compound of formula (I), each R^3 is chlorine, bromine, tert-butyl, trifluoromethyl or methoxy.

12. A method of claim 1 wherein for the compound of formula (I),
A is 4-chloro-3-trifluoromethylphenyl, 4-fluoro-3-trifluoromethylphenyl, 4-bromo-3-trifluoromethylphenyl, or 2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxin-6-yl;
B is phenylene, chlorophenylene or fluorophenylene;
L is -O-;
and
Q is cyano, C(O)-NH_2, or C(O)-NHMe.

13. A method of claim 1 wherein the compound of formula (I), is:
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)phenyl) urea,
N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)phenyl) urea,
N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)-2-chlorophenyl) urea,
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-carbamoyl-4-pyridyloxy)phenyl) urea,
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-carbamoyl-4-pyridyloxy)phenyl) urea,
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(1-hydroxy-2-(N-methylcarbamoyl)-4-pyridyl oxy)phenyl) urea,
N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,
N-(4-bromo-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-fluoro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyl oxy)-2-fluorophenyl) urea,

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyl oxy)-2-chlorophenyl) urea,

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-N'-(4-(2-cyano-4-pyridyloxy) phenyl) urea, or

N-(6-(2,2,4,4-tetrafluoro-4H-benzo[1,3]dioxinyl))-N'-(4-(2-cyano-4-pyridyloxy)-2-fluorophenyl) urea.

14. A method of any of claims 1-13 wherein a pharmaceutically acceptable basic salt of an organic acid of formula (I) is administered.

15. A method of claims 1-13 wherein a pharmaceutically acceptable basic salt of an organic acid of formula (I) is administered, selected from hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, methanesulfonic acid, trifluoromethanesulfonic acid, benzenesulfonic acid, p-toluene sulfonic acid (tosylate salt), 1-napthalene sulfonic acid, 2-napthalene sulfonic acid, acetic acid, trifluoroacetic acid, malic acid, tartaric acid, citric acid, lactic acid, oxalic acid, succinic acid, fumaric acid, maleic acid, benzoic acid, salicylic acid, phenylacetic acid, or mandelic acid.

16. The method of claim 1 wherein the compound of formula I is a pharmaceutically acceptable hydrochloride, benzenesulfonate, or methanesulfonate salt of

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-2-fluoro-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)phenyl) urea or

N-(4-chloro-3-(trifluoromethyl)phenyl)-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)phenyl) urea.

17. The method of claim 1 wherein the compound of formula (I), is a tosylate salt of N-(4-chloro-3-(trifluoromethyl)phenyl-N'-(4-(2-(N-methylcarbamoyl)-4-pyridyloxy)phenyl)urea.

18. A method of any of claims 1-17 comprising administering an additional pharmaceutical agent with the compound of formula (I) to a patient in need thereof.

19. A composition of claim 18, wherein the additional pharmaceutical agent is an anti-hyper-proliferative agent.

20. A method of any of claims 1-19 wherein said compound of formula (I) is administered to a patient in need thereof at an oral, intramuscular, intravenous, subcutaneous, or parenteral dosage which can range from about 0.1 to about 300 mg/kg of total body weight.

21. A method of any of claims 1-20, wherein said condition is restenosis following angioplasty.

22. A method of any of claims 1-20, wherein said condition is graft rejection following transplantation of a donor tissue into a host.

23. A method for treating or preventing a disease or condition in mammal, or a mammalian cell thereof, which is mediated by platelet-derived growth factor receptor-beta, comprising:

administering to a subject in need thereof, an effective amount of

an aryl urea compound of formulae X, Y, ZA, ZB, ZC or ZD,

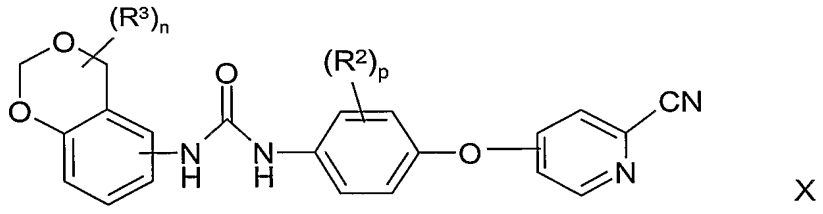
a salt form of a compound of formulae X, Y, ZA, ZB, ZC or ZD,

an isolated or mixed stereoisomer of a compound of formulae X, Y, ZA, ZB, ZC or ZD ,

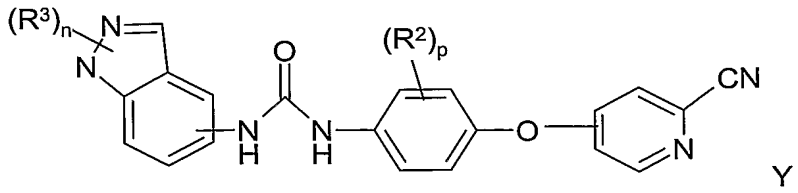
an ester of a compound of formulae X, Y, ZA, ZB, ZC or ZD,

a metabolite of a compound of formulae X, Y, ZA, ZB, ZC or ZD, or

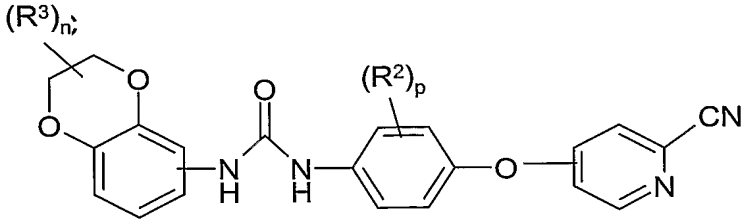
a prodrug of a compound of formulae X, Y, ZA, ZB, ZC or ZD,



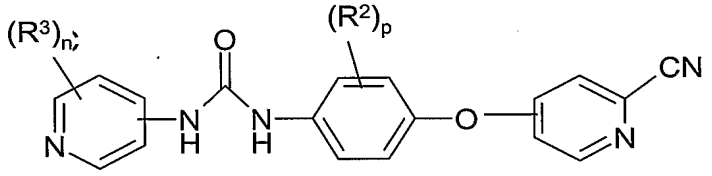
X



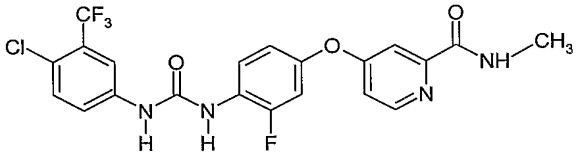
Y



ZA

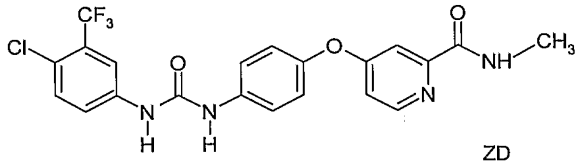


ZB



ZC

and



ZD

wherein

each R^3 is independently halogen or trifluoromethyl and

each R^2 is independently fluorine, chorine, bromine, methyl, trifluoromethyl, methoxy, CN or NO_2.

the variable n is 0, 1, 2, 3 or 4 and

the variable p is 0 , 1 or 2.

24. A method of claim 23 wherein a pharmaceutically acceptable basic salt of an organic acid of formula (I) is administered.

25. A method of claim 23 wherein a pharmaceutically acceptable basic salt of an organic acid of formula (I) is administered, selected from hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, methanesulfonic acid, trifluoromethanesulfonic acid, benzenesulfonic acid, p-toluene sulfonic acid (tosylate salt), 1-napthalene sulfonic acid, 2-napthalene sulfonic acid, acetic acid, trifluoroacetic acid, malic acid, tartaric acid, citric acid, lactic acid, oxalic acid, succinic acid, fumaric acid, maleic acid, benzoic acid, salicylic acid, phenylacetic acid, or mandelic acid.

26. A method of any of claims 23-25, wherein said condition is restenosis following angioplasty.

27. A method of any of claims 23-25, wherein said condition is graft rejection following transplantation of a donor tissue into a host.

28. An intravascular stent for introduction into a vascular lumen, comprising:
an elongated body having surfaces, wherein said surfaces comprise an effective amount of a compound of claim 1 or 23 to inhibit restenosis.

29. An intravascular stent according to claim 28, wherein a substrate comprising said compound is on said surface.

30. An intravascular stent according to claim 29, wherein said substrate is impregnated with said compound.

31. An intravascular stent of claim 28, wherein said elongated body is substantially cylindrical.

32. An intravascular stent according to claim 28, wherein the surfaces comprise a metallic scaffold which is cylindrical and has inner and outer sides.